§9. Consideration on the Ablation Flow Characteristics of Ice Pellets in the Injection-Angle Controllable Experiments

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Due to four experimantal conditions with the combination of two (clockwise and counter-clockwise) toroidal field directions and two plasma current directions, the ablation cloud seems to rotate to the electron diamagnetic direction poloidally, and to the opposite to the plasma current direction toroidally, not flowing parallel to the magnetic field lines of the torus, within a certain injection angle ($z \leq 10.0$ cm).[1]

Here, we will consider about this tail structure. In the present pellet injection experiment, the number of hydrogen atoms within the ablation cloud may be around $3\text{x}10^{19}$ particles. The penetration depth (D) is supposed to be around half of plasma radius; that is, 10.0~20.0 cm. If we consider a cylindrical-like tube in Fig. 1, the volume of a cloud region will be estimated to be $D\text{x}W\text{x}L \approx (30\sim100)L$ cm^3, here, 'W' is a width of the cloud in vertical direction and 'L' is the length of the tail in toroidal direction.

By taking a result of measurement in other experiment into consideration, the temperature around the ablation cloud is assumed to be ~1 eV, and the velocity of neutral particles is calculated to be about 10^6 cm/s. Especially, if the length 'L' is assumed to be 100 cm as observed by CCD cameras, the characteristic time of the flow becomes ~100 µsec, and neutral cloud density is around $(0.3\sim1)\text{x}10^{16}$ particles/cm3. This density is much higher than the bulk plasma density, that is, $(1\sim3)\text{x}10^{13}$ particles/cm^3.

If we assume the toroidal and poloidal rotation velocities of OH plasma to be of the order of 10 km/s and 3 km/s, respectively, a characteristic length of the rotation in the characteristic time of 50~100 µsec will roughly coincide with that of the tail mode structure.

Consideration on various cross sections including charge exchange, ionization and elastic collisions leads us to the following conclusion. When the hydrogen ion energy is $1\sim10^3$ eV, cross sections both for elastic scattering and charge exchange are the same order with each other, and the maxwellian rate coefficient for charge exchange is larger than that for electron ionization over wide energy range. Thus, it seems reasonable to conclude that this phenomenon may be caused by the condition of charge exchange equilibrium of hydrogen ions and neutrals at high density regime, and by the toroidal and poloidal rotation by the plasma potential. In order to make this phenomenon more clear, measurements of the potential profile and time dependence of the ablation flow profile by using an HIBP and a high speed image convertor camera have been started.

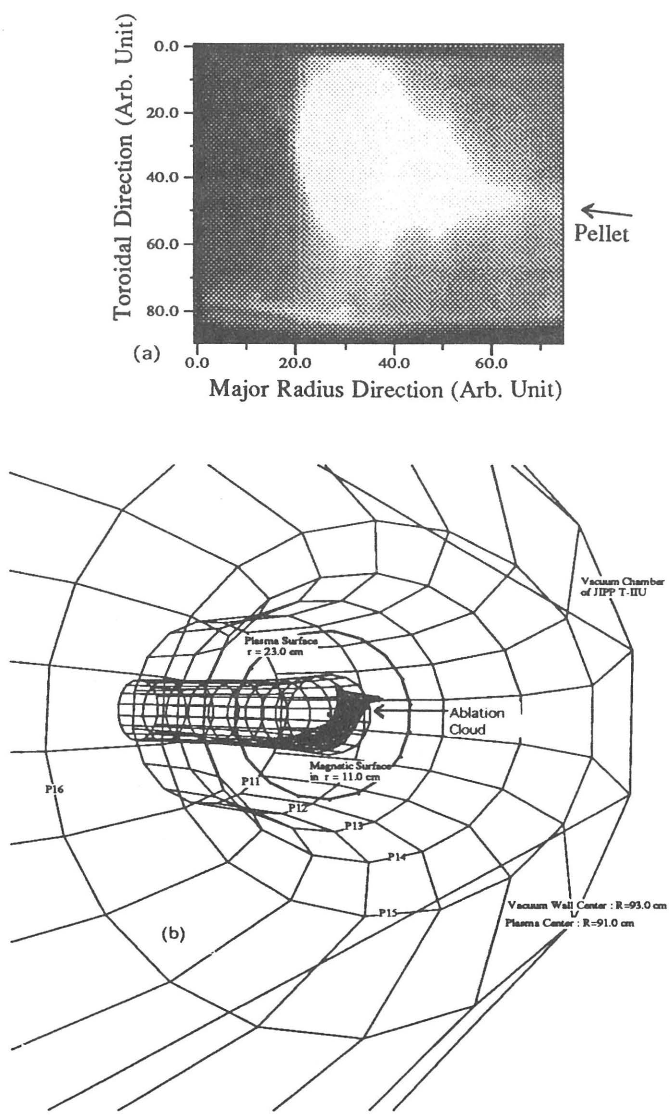

Fig. 1. (a) Ablation cloud taken from the upper window. (b) 3-D schematic view of the ablation cloud looking from the tangential direction.

Reference
1) Sakakita, H., et al.: Ann. Rep. of NIFS (Apr. 1992-Mar. 1993) p.130